

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11) Publication number:

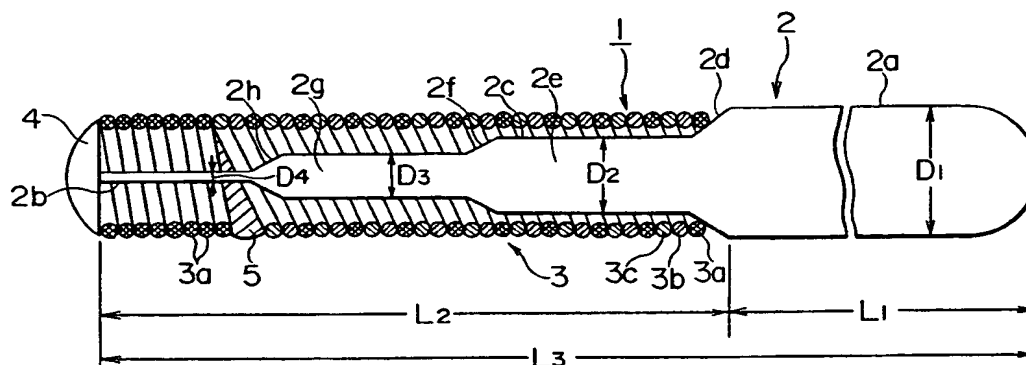
**0 666 086 A1**

(12)

**EUROPEAN PATENT APPLICATION**(21) Application number: **94101605.7**(51) Int. Cl.<sup>6</sup>: **A61M 25/00, A61M 25/01**(22) Date of filing: **03.02.94**(43) Date of publication of application:  
**09.08.95 Bulletin 95/32**(64) Designated Contracting States:  
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**CH-1202 Genève (CH)**(54) **Guide wire for medical purpose and manufacturing process of coil thereof.**

(57) A guide wire for medical purposes having a proximal section and a distal section and formed by inserting all or a portion of a slender and flexible shaft into a coil and fixing the shaft to the coil, wherein the coil is a multiple-wire coil consisting of at least 2 wire rods, at least one of these wire rods is

made of a material which is opaque against radioactive rays such as X ray, and a portion of the coil closer to the distal section of the shaft is a single-wire coil consisting of only a wire rod made of the radiopaque material.

**FIG. 2**

## FIELD OF THE INVENTION

The present invention relates to a guide wire for medical purpose used for introducing a catheter into a blood vessel system, especially into a human heart blood vessel system, and a manufacturing process of a coil constituting the guide wire.

## BACKGROUND OF THE INVENTION

For the purpose of introducing a catheter into a blood system for angiography, conventionally a guide wire has been used to more safely and more accurately carry out the introduction. The guide wire is effective to relatively thick blood vessels or those having relatively simple branches or bending in a relatively simple form, but sometimes it is very difficult to carry a catheter into a depth of a blood vessel branching very minutely such as a coronary of a human heart, and especially for substantially stenosed portions a guide wire based on a completely different concept is required. Especially in case of guide wire used for a catheter for blood vessel forming in substantially stenosed sections, it is essential that a portion near a tip of the guide wire should be opaque against radioactive rays such as X-ray in order to accurately detect a stenosed portion. To achieve the object as described above, a guide wire as disclosed, for instance, in Japanese Patent Publication NO. 25024/1992 has been proposed.

In the conventional type of guide wire as described above, 2 pieces of coil are connected to a section near a tip of shaft made of metal having a high twistability, and of the two pieces of coil, the one closer to the tip is made of a radiopaque material so that the guide wire will be provided with high flexibility and high bending capability as well as be easily detected by radioactive rays, through introduced various devices. However, in this type of guide wire, 2 coils made of different materials are artificially coupled and connected by means of screwing or soldering, so particular considerations are required to maintain mechanical safety and strength in the connected section, and in addition, because mechanical characteristics of the connected section becomes discontinuing, when a guide wire passes through a blood vessel having an extremely small curvature, sometimes passage becomes impossible due to discontinuity of bending radius in this connected section. Namely in Fig.1A and Fig.1B each diagrammatically illustrating the situations where the problem as described occurs, if the connected section 51 of the guide wire 50 is too hard, it can not follow bending of a blood vessel 52 and can not pass through the section (Fig.1A), and on the other hand, if the connected section 51 is too soft, it bends and passage be-

comes impossible also in this case (Fig.1B).

## OBJECT AND SUMMARY OF THE INVENTION

The present invention was made in the light of the circumstances as described above, and it is an object of the present invention to provide a guide wire for medical purposes which has no connection and can pass through even a blood vessel having an extremely small curvature.

A guide wire for medical purposes according to this invention is a guide wire for medical purposes having a proximal section and a distal section, wherein all or a portion of slender and flexible shaft is inserted into and fixed in a coil to achieve the above-described object, the coil is a multiple-wire coil comprising at least two or more wire rods, of these wire rods at least one wire rod is made of a radiopaque material, and a portion of the coil closer to the distal section of the shaft is a single-wire coil made of the radiopaque material. In one mode of carrying out this invention, the radiopaque material is made of any of alloy containing platinum as a main component, alloy containing gold as a main component, alloy containing tungsten as a main component, and lead.

Furthermore in another embodiment of the present invention, a portion of single-wire coil consisting of a wire rod made of the radiopaque material and an edge portion consisting of a different wire rod are contacted and fixed to each other by means of soldering. Furthermore in a different embodiment of the present invention, the distal section of the shaft comprises two portions jointed to each other in the axial direction.

A guide wire for medical purposes according to this invention is a guide wire for medical purposes having a proximal section and a distal section, wherein all or a portion of slender and flexible shaft is inserted into and fixed in a coil to achieve the above-described object, the coil is a single-wire one consisting of one wire rod having no connection, and a portion of this coil closer to the distal section of the shaft is made of the material opaque against radioactive rays such as X ray. And in a still different embodiment of the present invention, a wire rod of a coil comprises an inner layer and an outer layer, and a portion of the inner layer closer to the distal section of the shaft is made of radiopaque material, and the outer layer and a portion of the inner layer other than that closer to the distal section of the shaft is made of a radiotransparent material.

In the different embodiment of the present invention, the radiopaque material is made of any of alloy containing platinum as a main component, alloy containing gold as a main component, alloy containing tungsten as a main component, and

lead.

Namely in the invention as described above, the coil is a multiple-wire coil consisting of at least 2 wire rods each having no connection or a single-wire coil consisting of a wire rod having no connection, so that the coil has no remarkable irregularity in bending radius when bent like that of a conventional type of guide wire having a connection and the bending ratio is kept at a constant level, so that the coil can easily pass through even a minute blood vessel having an extremely small curvature. Also as a portion of coil closer to the shaft distal section is made of a radiopaque material, when fluoroscopy is carried out, the section can easily be distinguished from the surrounding minute vessel, and also a position of the guide wire itself can easily be detected clearly. For this reason, a guide wire can easily be passed through even a blood vessel having an extremely small curvature, and is convenient especially when introducing a catheter into a minute blood vessel such as those in a human heart.

Also it is an object of the present invention to provide a coil manufacturing method which makes it possible to produce a coil constituting the guide wire.

In the coil manufacturing method according to the present invention, in order to achieve the object as described above, when producing coils each for a guide wire, a wire rod made of a radiotransparent material and a wire rod made of a radiopaque material are jointed by soldering one edge section of a wire rod to an opposing edge section of another wire rod, and these jointed two wire rods are pulled through a die to make them into a wire rod having a smaller diameter, which is manufactured into a coil. In one embodiment of the present invention, when manufacturing a coil for guide wire, a wire rod made of a radiopaque material is inserted into one side of the thin tubular outer layer made of a radiotransparent material and a wire rod made of a material which is the same as that of the outer layer is inserted into the other side thereof, and then the complex layer is pulled through a die to form a wire rod having a small diameter, which is manufactured into a coil. With these operations, a coil constituting a guide wire can easily be manufactured.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1A and Fig.1B are drawings each illustrating effect of a conventional type of guide wire;

Fig.2 is a longitudinal front sectional view of a guide wire illustrating an embodiment of the present invention, but lacking a portion thereof;

Fig.3 is a drawing illustrating effect of a guide wire;

Fig.4 is a longitudinal front sectional view of a guide wire illustrating another formation of the shaft, but lacking a portion thereof;

Fig.5 is a longitudinal front sectional view of a guide wire illustrating another embodiment of the present invention, but lacking a portion thereof;

Fig.6 is a schematic diagram illustrating a manufacturing process of the coil above;

Fig.7 is a longitudinal front sectional view of a guide wire illustrating a further different embodiment of the present invention; and

Fig.8 is a schematic diagram illustrating a manufacturing process of the coil above.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 2, designated at the reference numeral 1 is a guide wire, which comprises a slender and flexible shaft 2 made of such a material as stainless steel, a coil 3, and a plug 4. The shaft 2 comprises a proximal section 2a, a distal section 2b and an intermediate section 2c, and the intermediate section 2c and the distal section 2b are tapered toward the plug 4 by means of polishing. A length  $L_1$  of the proximal section 2a of the shaft 2 is 1400 mm, while a length  $L_2$  of other portion thereof is 350 mm, so the full length  $L_3$  is 1750 mm. The proximal section 2a has a cylindrical form having a diameter  $D_1$  of 0.35 mm. The intermediate section 2c comprises a cylindrical form section 2e with the diameter reduced via the tapered section 2d to  $D_2$  of 0.19 mm and a cylindrical form section 2g with the diameter reduced via the tapered section 2f to  $D_3$  of 0.13 mm, and the cylindrical distal section 2b with the diameter reduced via the tapered section 2h at the tip of this cylindrical section 2g to 0.05 mm is provided monolithically. At the tip of the distal section 2b is fixed the plug 4 having a roundness toward the tip.

The coil 3 is a multi-stripe one consisting of 3 wire rods each having no connection like that in the conventional type of coil. Of these, a wire rod 3a is made of a heavy metal such as, for instance, alloy containing platinum as a main component, alloy containing gold as a main component, alloy containing tungsten as a main component, or lead, and other two wire rods 3b, 3c are made of a material such as stainless steel, SUS 304, etc., which X ray can pass through. Also the coil 3 is a single-wire one consisting of only wire rod 3a in the portion closer to the distal section 2b of the shaft 2, because the wire rods 3b and 3c are gradually reduced and finally disappear in this portion. As the wire rod 3b, 3c gradually decrease and finally disappear, the coil 3 can maintain the bending ratio at a constant level. The number of wires in the coil

3 should be decided in a range where a black stripe, which is formed by the wire rod 3a made of a radiopaque material, is practically effective when actually fluoroscoped. But the number should preferably be not more than 6. In the coil 3 formed as described above, a tip of wire rod 3a made of a radiopaque material is fixed to the plug 4 in the distal section 2b of the shaft 2, while a base of the opposite side is fixed to the tapered section 2d of the shaft 1.

In Fig.2, a portion 5 shadowed with inclined lines is a soldered connection filled in a gap formed between edge sections of wire rods 3b,3c each gradually decreasing and the wire rod 3a formed into a single-wire coil, and without this soldered connection 5, homogeneity in bending may be lost when inserted into a blood vessel, or blood may easily come into the coil 3, which may become a cause of thrombosis, but these problems can be solved by filling the soldered connection 5 in the gap. Also, by filling the solder connection 5 therein, the distal section 2b of the shaft 2 is soldered to the coil 3, so that the fixation between the coil 3 and the shaft 2 is more tightly and more safely performed.

When the guide wire 1 having the configuration as described above is inserted into a blood vessel 22 having an extremely small curvature as shown in Fig.3, the guide wire smoothly advances in a blood vessel 52 and passes through even a bending section. This is because the coil 3 has no connection like that in a conventional type of coil and the bending ratio thereof is maintained at a constant level. Also, in the guide wire 1, the wire rod 3a for coil 3 made of a radiopaque material is shown under fluoroscopy with X ray as a black section in the distal section and as spaced black stripes in other section where the wire rod 3a is coiled together with other wire rods 3b,3c, so that an operator can quite easily distinguish the guide wire from the surrounding blood vessel 22. For this reason, the operator can recognize a bending section positional relations in a stenosed section in the blood vessel 52 with the help by contrast media discharged from a catheter, and also can recognize the position of the guide wire 1 itself quite clearly.

Fig.4 is a drawing illustrating an example of another formation of the shaft, and the distal section 2b of this shaft 2 comprises two portions. Namely, a distal section 2b<sub>1</sub> provided via a tapered section 2h of the cylindrical portion 2g forms a short section, and a cylindrical distal section 2b<sub>2</sub> which is an independent body having almost the same length as that of the distal section 2b shown in Fig.1 is jointed with and fixed to the distal section 2b<sub>1</sub> in the axial direction. Other portions in this configuration are the same as those in Fig.2.

Fig.5 shows another embodiment of the present invention. In a guide wire 11 according to this embodiment, a coil 13 is a single-wire one consisting of one wire rod having no connection. A portion of a wire rod 15 constituting the coil 13 closer to the distal section 2b of the shaft 2 consists of a wire rod 15a made of a material which is different from such a material as stainless steel and X ray can not pass through; namely in this case such a heavy metal as alloy containing platinum as a main component, alloy containing gold as a main component, alloy containing tungsten as a main component, or lead, while a portion of a wire rod 15 other than the portion closer to the distal section 2b of the shaft 2 consists of a wire rod 15b made of a material which has the same quality as stainless steel or the like or such a material as copper which can industrially be utilized and X ray can pass through. Configuration in other portions of the shaft 2 is the same as that in the embodiment shown in Fig.2. Also with this guide wire 11, the same effect as that with the guide wire 1 can be expected.

To manufacture the coil 13 as described above, as shown in Fig.6, at first an edge section of the wire rod 15a made of a radiopaque material is moved closer to an opposite edge section of the wire rod 15b made of a radiotransparent material (A). The both edge faces are contacted and fixed by means of welding, and then the metal thrusting toward the radial direction is removed to realize a smooth surface (B,C). Then, the wire rods 15a, 15b fixed to each other is pulled through a die 18 to obtain a wire rod having a smaller diameter, which is finished to a wire rod 15 having a necessary outer diameter (D,E). Outer diameter of the wire rod 15 is preferably in a range from 0.03 to 0.15 mm. Then by coiling the wire rod 15 manufactured as described above in the usual way, formed is the continuous and homogeneous coil 13 consisting of the wire rod 15, of which a portion is radiopaque (F).

Fig.7 shows a further different embodiment of the present invention. A wire rod 29 constituting a coil 23 of a guide wire 21 in this embodiment comprises an inner layer 25 and an outer layer 26. The outer layer 26 is made of such a material as stainless steel and has a tubular form, while a portion of the inner layer 25 closer to the distal section 2b of the shaft 2 is made of a material 25a which is different from such a material as stainless steel and X ray can not pass through; namely in this case such a material as alloy containing platinum as a main component, alloy containing gold as a main component, alloy containing tungsten as a main component, or lead, while a portion of the inner layer 25 other than the portion closer to the distal section 2b of the shaft 2 is made of a

material 25b which has the same quality as stainless steel or of a material like copper which can industrially be utilized and X ray can pass through. Configuration of the shaft 2 in other portions is the same as that in the embodiment shown in Fig.2.

To manufacture the coil 23 as described above, as shown in Fig.8, at first the slender and tubular outer layer 26 is formed with such a material as stainless steel SUS 304 (A), and the wire rod 25a made of such a metal or other radiopaque material as described above is inserted from one side of this outer layer 26. Also a wire rod 25b made of a material which has the same quality as stainless steel or other material constituting the outer layer 26 or of a radiotransparent material like copper which can industrially be utilized is inserted into the outer layer 26 from the other side thereof, and an edge face at the tip thereof is moved closer and contacted to that of the wire rod 25a (B,C). Then, the complex layer comprising the outer layer 26 and the inner layer 25 formed as described above is pulled through a die 28 to obtain a wire rod having a smaller diameter, which is finished to a wire rod 29 having a necessary outer diameter (D,E). The outer diameter of the wire rod 29 is preferably in a range from 0.03 to 0.15 mm like in the embodiment shown in Fig.5. Assuming that 1 is a cross-sectional area of the wire rod 29 in the portion with the wire rod 25a made of a radiopaque material, it is preferable that a cross-sectional area of the wire rod 25b made of a radiotransparent material and constituting the inner layer 25 is 0.2 or more. Then, by coiling the wire rod 29 formed as described above, the continuous and homogeneous coil 23, in which X ray can not pass through a portion of the inner layer 25, is formed as shown in (F).

In the configuration described above, the wire rod 25b as the inner layer 25 made of a radiotransparent material is not always necessary and the portion may be hollow. Furthermore, a radiotransparent material for the wire rod 25b is not always limited to a metal, and non-metallic material such as powder of barium sulfate or bismuth oxide, or other substance in a solidified state may be used for that purpose. In the coil 23 formed as described above, the tip of the wire rod 25a made of a radiopaque material is fixed to the plug 4, while a proximal edge of the wire rod 25b made of a radiotransparent material is fixed to the tapered section 2d of the shaft 1.

Although details of the embodiments are not shown in Fig. 5 and Fig. 7, the distal section 2b of the shaft 2 may comprise 2 portions like in the embodiment shown in Fig.4.

Although particular preferred embodiments of the present invention have been disclosed in detail for illustrative purposes, it will be recognized that

variation or modification of the disclosed apparatus, including the rearrangement of part, lie within the scope of the present invention.

## 5 Claims

1. A guide wire for medical purposes having a proximal section and a distal section and formed by inserting all or a portion of a slender and flexible shaft into a coil and fixing the shaft to the coil; wherein said coil is a multiple-wire one consisting of at least 2 wire rods, at least one of these wire rods is made of a material which is opaque against radioactive rays such as X ray, and a portion of the coil closer to a distal section of said shaft is a single-wire coil consisting of a wire rod made of a radiopaque material.
2. A guide wire for medical purposes according to Claim 1, wherein the radiopaque material is made of any of alloy containing platinum as a main component, alloy containing gold as a main component, alloy containing tungsten as a main component, and lead.
3. A guide wire for medical purposes according to Claim 1, wherein an edge of a portion of single-wire coil consisting of a wire rod made of a radiopaque material and that of other portion is connected by means of soldering.
4. A guide wire for medical purposes according to Claim 1, wherein a distal section of the shaft comprises two portions which are joined in the axial direction and fixed to each other.
5. A guide wire for medical purposes having a proximal section and a distal section and formed by inserting all or a portion of a slender and flexible shaft into a coil and fixing the shaft to the coil, wherein said coil is a single-wire coil consisting of a wire rod having no connection and a portion of the coil closer to the distal section of the shaft has a material which is opaque against radioactive rays such as X ray.
6. A guide wire for medical purposes according to Claim 5, wherein a wire rod for the coil comprises an inner layer and an outer layer, a portion of the inner layer closer to the distal section of the shaft is made of a radiopaque material, and the outer layer as well as a portion of the inner layer other than the portion closer to the distal section of the shaft is made of a radio-transparent material.

7. A guide wire for medical purposes according to Claim 5, wherein the radiopaque material is made of any of alloy containing platinum as main component, alloy containing gold as a main component, alloy containing tungsten as a main component, and lead. 5
8. A method of manufacturing a coil for the guide wire for medical purposes according to Claim 5 comprising steps of contacting and fixing an edge face of a wire rod made of a radiotransparent material to an edge face of a wire rod made of a radiopaque material by means of welding, pulling the two wire rods connected to each other through a die to obtain a wire rod having a smaller diameter, and forming the wire rod into a coil. 10 15
9. A method of manufacturing a coil for the guide wire for medical purposes according to Claim 6 comprising steps of inserting a wire rod made of a radiopaque material into an outer layer of a slender and tubular form made of a radiotransparent material from one end thereof, inserting a wire rod made of a material which is the same as that of the outer layer from the other end thereof, then pulling these complex layers through a die to obtain a wire rod having a smaller diameter, and forming the wire rod into a coil. 20 25 30

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FIG. 1A

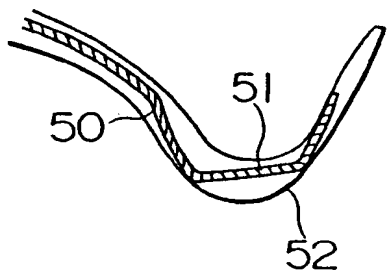
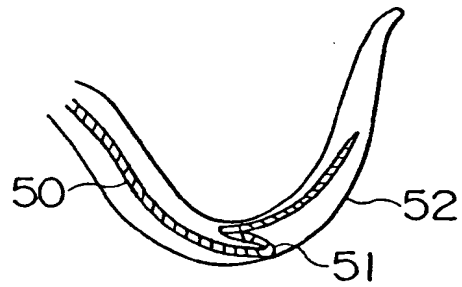


FIG. 1B



PRIOR ART

FIG. 3

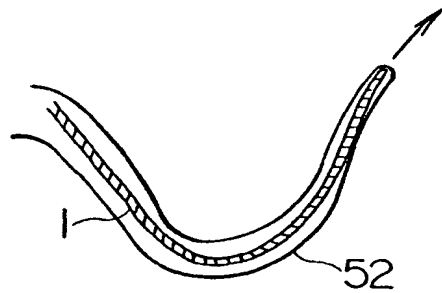


FIG. 2

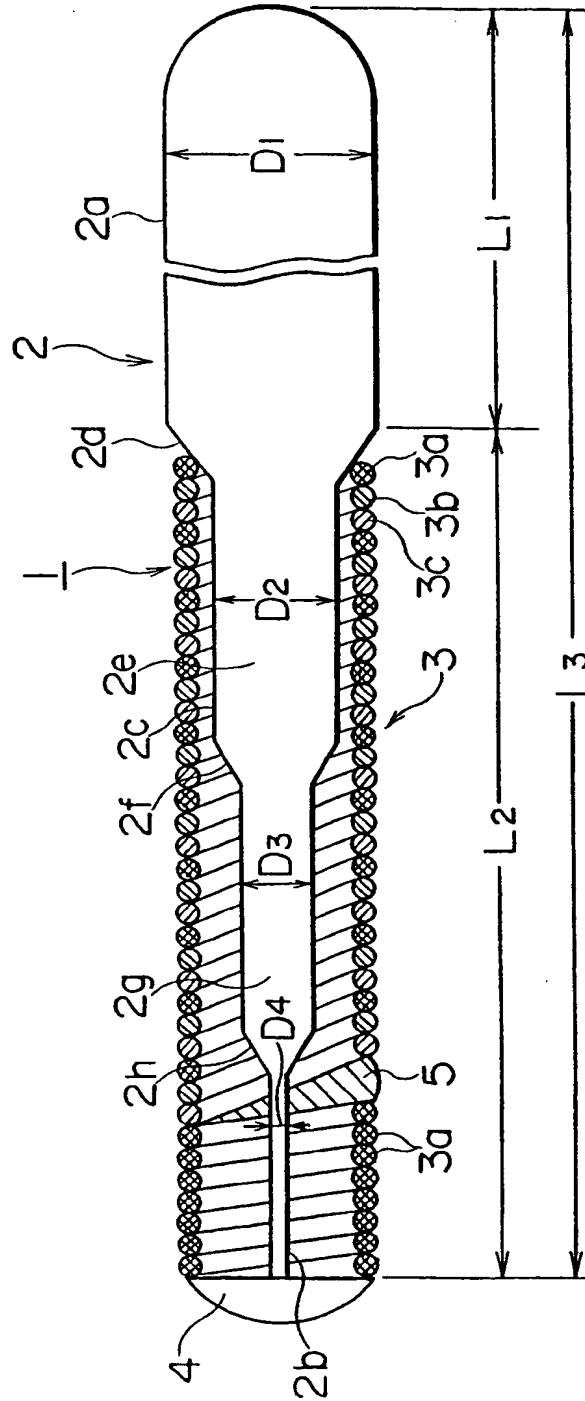




FIG. 4

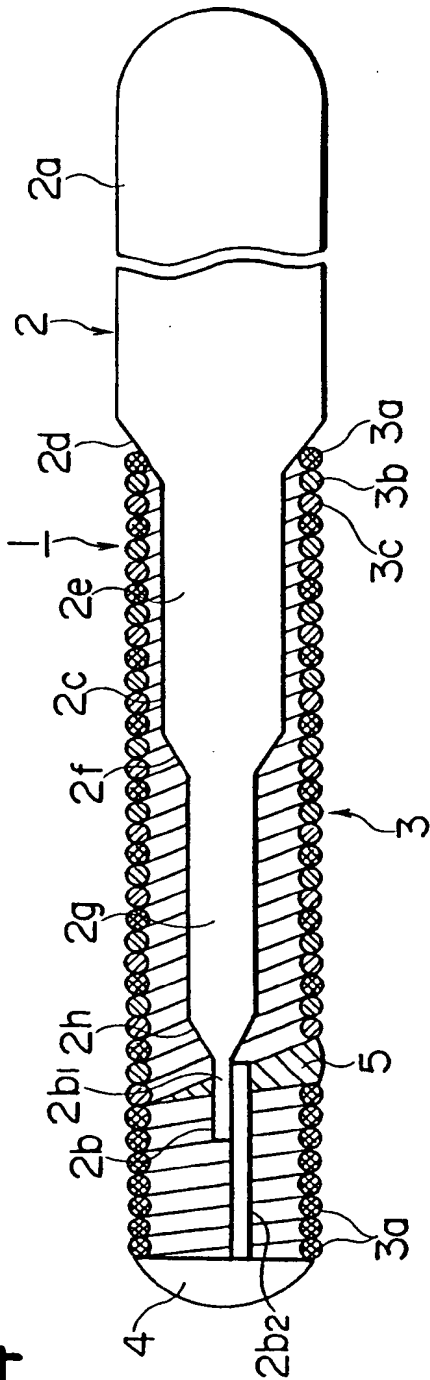


FIG. 5

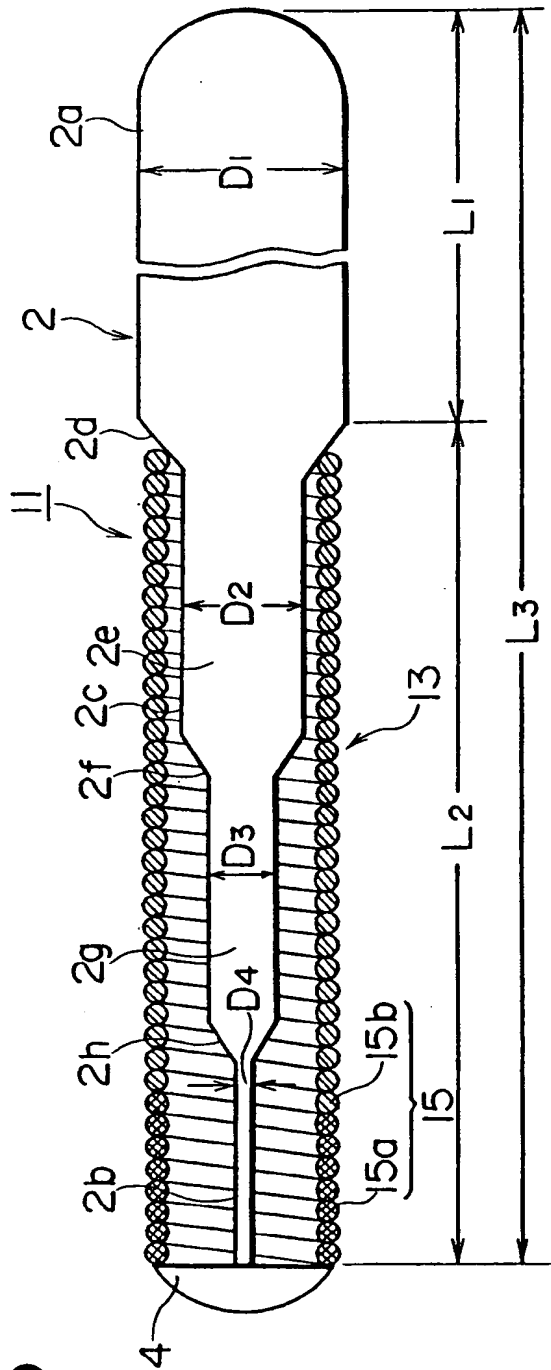


FIG. 6

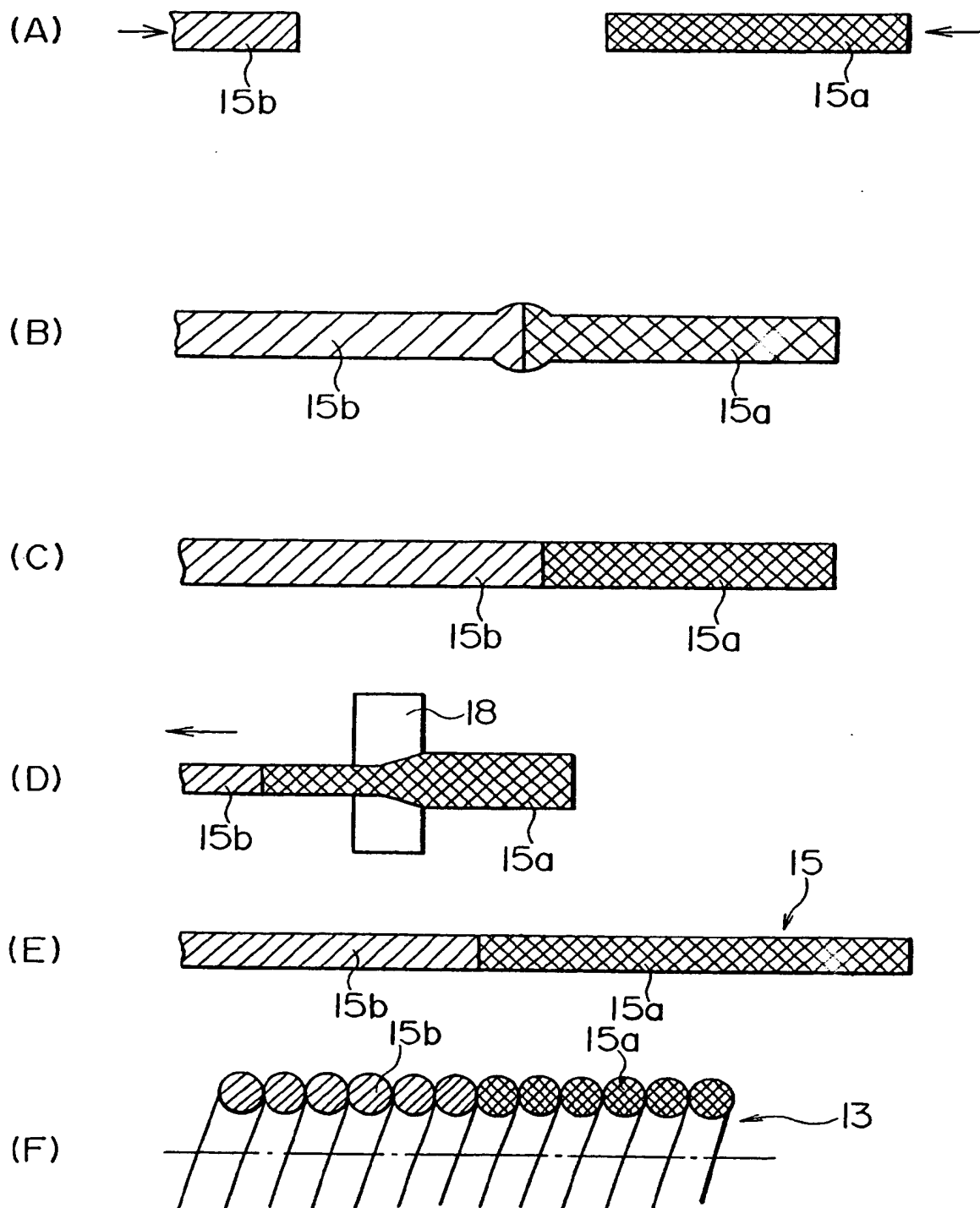


FIG. 7

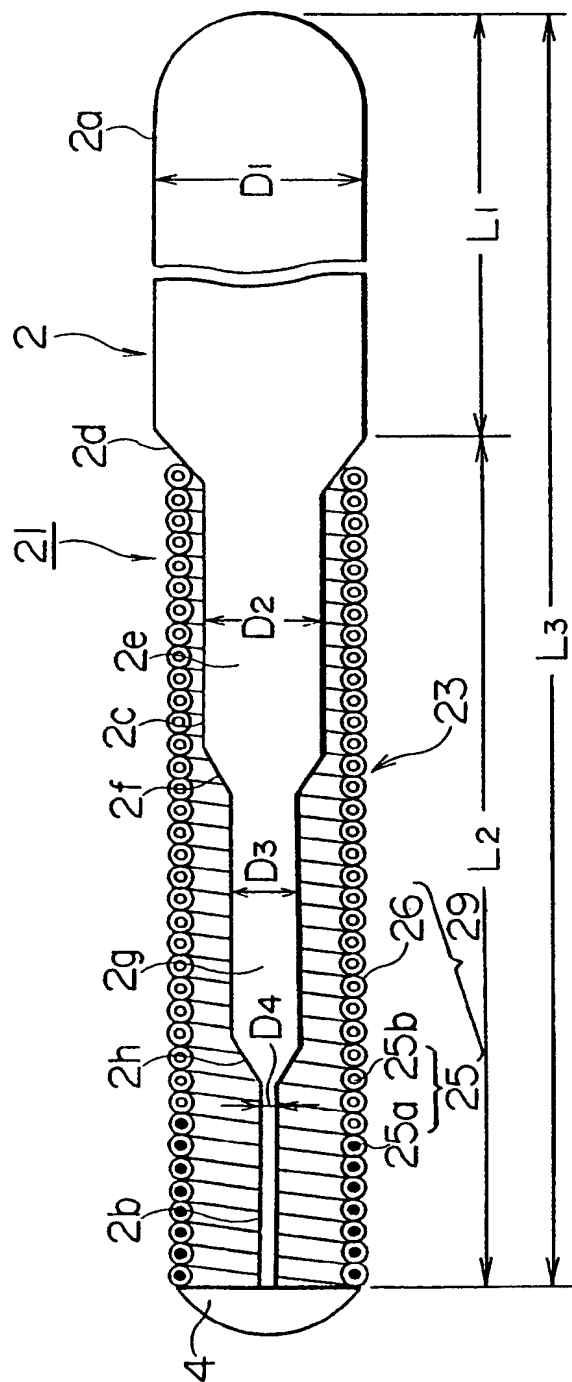
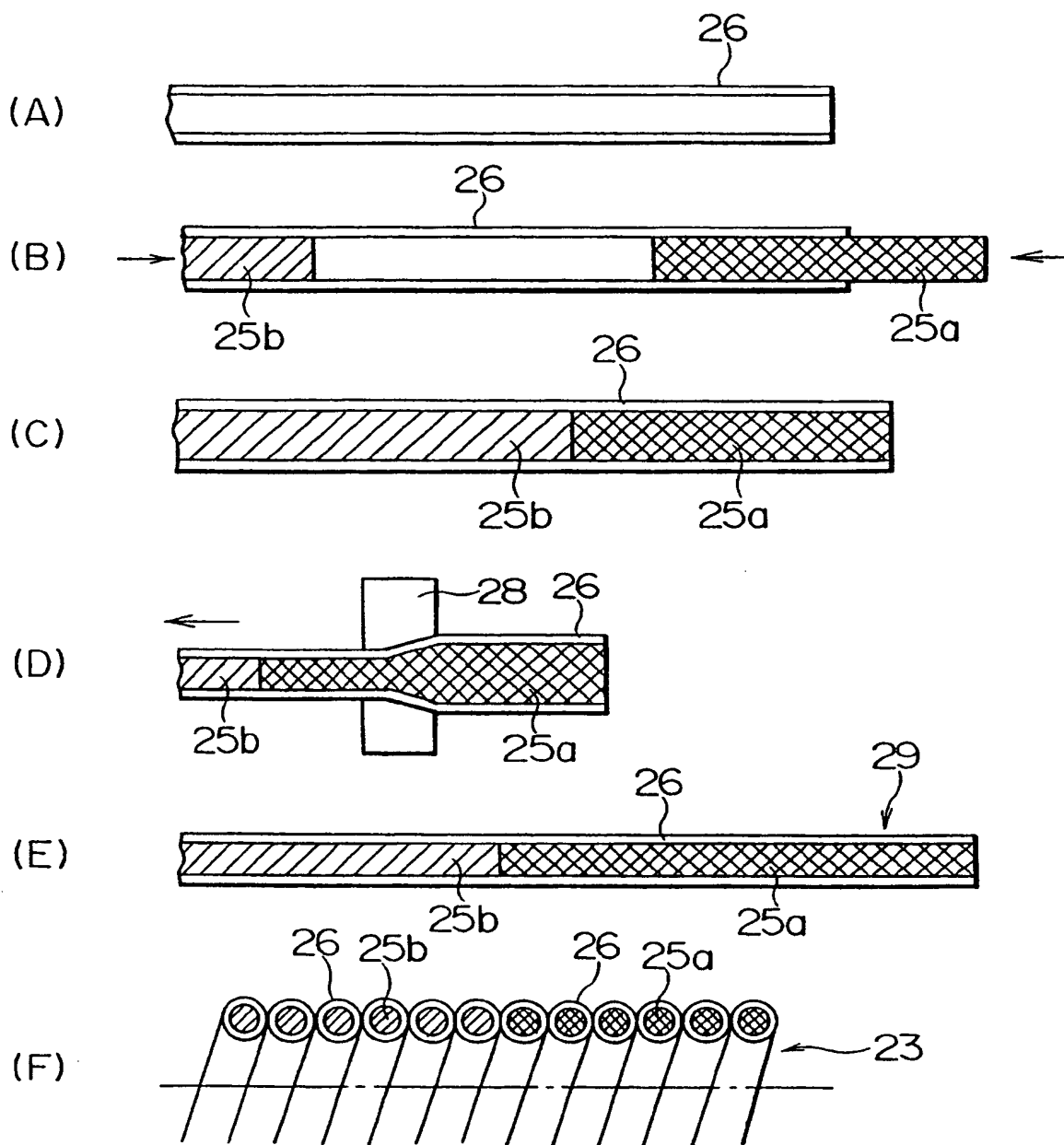


FIG. 8





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## EUROPEAN SEARCH REPORT

Application Number  
EP 94 10 1605

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-4 922 924 (GAMBALE) * the whole document *	1-4	A61M25/00 A61M25/01
A	---	5,7	
X	US-A-5 174 302 (PALMER) * column 4, line 17 - line 42; figure 2 *	1-3	
A	---	5,7	
X	WO-A-93 19663 (BOSTON SCIENTIFIC) * page 5, line 12 - page 6, line 25; figure 1 *	1,2	
A	---	8,9	
	US-A-4 917 285 (SHOSIE) * column 4, line 20 - line 68; figure 1 *		
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			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			A61M B21C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 1 July 1994	Examiner Kousouretas, I
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